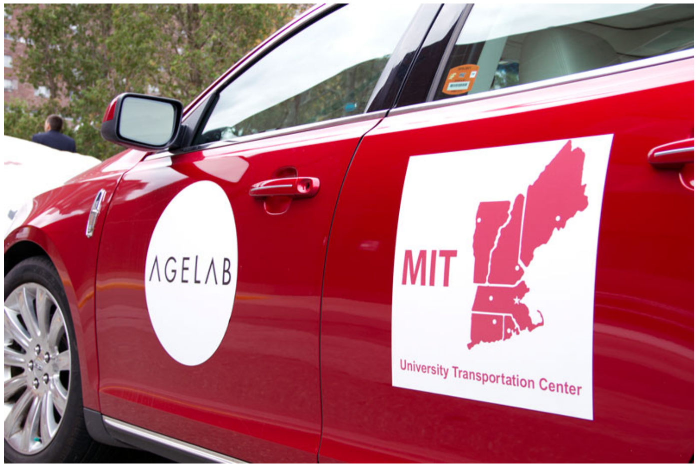
Implications of Autonomous Driving: Could "We" be a Near Term Threat?

Bryan Reimer, Ph.D.
MIT AgeLab & New England University Transportation Center



JITI Safer Vehicle Seminar
Washington, DC

March 20, 2013

Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu

The Ever Changing Vehicle

- Over the past 100 or so years, while the outward appearance of vehicles has changed, we have seen very little change in how drivers interface with vehicle.
- What do trends in automation, advanced driver assistance systems and information connectivity tell us about expectations for the next 25 or more years?

Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu

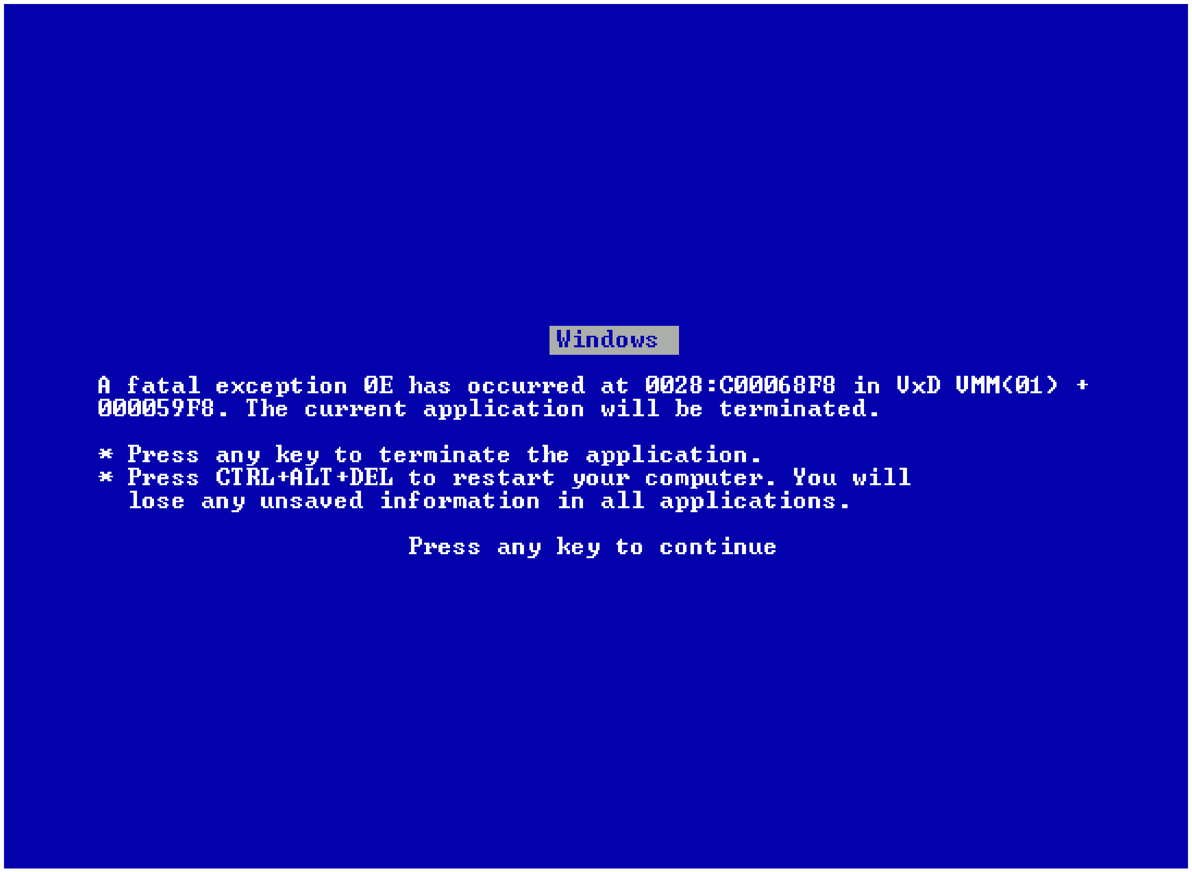
A Partial List of Concepts To Consider

In no particular order of significance

- Trust in technology
- The theory of experience
- Lessons from other domains
- Education
- Human capabilities

Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu

My Trust in Technology



Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu

Automation and the Big Red Button: To Trust or Not?

- In many situations automation will outperform human operation, but will the driver trust it?

- How will one choose when to or when not to provide / accept autopilot control?

- Experiential learning does not yet exist.

Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu

Experience

Today
VMT = VMD

Tomorrow?
VMT ≠ VMD

Vehicle Miles Traveled (VMT)

Vehicle Miles Driven (VMD)

Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu

A Case Study: The FAA

A Comparative Analysis of Flightdecks With Varying Levels of Automation

Federal Aviation Administration Grant 93-G-039

Final Report

8 June 2000

Ken Funk
Oregon State University

Beth Lyall
Research Integrations, Inc

RESEARCH INTEGRATIONS
INCORPORATED

Prepared for the FAA Chief Scientific and Technical Advisor for Human Factors, AAR-100

Technical Monitors:

John Zalenchak
Tom McCloy
Eleana Edens

U.S. Department
of Transportation
Federal Aviation
Administration

SAFO
Safety Alert for Operators

SAFO 13002
DATE: 1/4/13

Flight Standards Service
Washington, DC

http://www.faa.gov/other_visit/aviation_industry/airline_operators/airline_safety/safo

A SAFO contains important safety information and may include recommended action. SAFO content should be especially valuable to air carriers in meeting their statutory duty to provide service with the highest possible degree of safety in the public interest. Besides the specific action recommended in a SAFO, an alternative action may be as effective in addressing the safety issue named in the SAFO.

Subject: Manual Flight Operations

Purpose: This SAFO encourages operators to promote manual flight operations when appropriate.

Background: A recent analysis of flight operations data (including normal flight operations, incidents, and accidents) identified an increase in manual handling errors. The Federal Aviation Administration (FAA) believes maintaining and improving the knowledge and skills for manual flight operations is necessary for safe flight operations.

Discussion: Modern aircraft are commonly operated using autoflight systems (e.g., autopilot or autothrottle/autothrust). Unfortunately, continuous use of those systems does not reinforce a pilot's knowledge and skills in manual flight operations. Autoflight systems are useful tools for pilots and have improved safety and workload management, and thus enabled more precise operations. However, continuous use of autoflight systems could lead to degradation of the pilot's ability to quickly recover the aircraft from an undesired state.

Operators are encouraged to take an integrated approach by incorporating emphasis of manual flight operations into both line operations and training (initial/upgrade and recurrent). Operational policies should be developed or reviewed to ensure there are appropriate opportunities for pilots to exercise manual flying skills, such as in non-RVSM airspace and during low workload conditions. In addition, policies should be developed or reviewed to ensure that pilots understand when to use the automated systems, such as during high workload conditions or airspace procedures that require use of autopilot for precise operations. Augmented crew operations may also limit the ability of some pilots to obtain practice in manual flight operations. Airline operational policies should ensure that all pilots have the appropriate opportunities to exercise the aforementioned knowledge and skills in flight operations.

Recommended Action: Directors of Operations, Program Managers, Directors of Training, Training Center Managers, Check Pilots, Training Pilots, and flightcrews should be familiar with the content of this SAFO. They should work together to ensure that the content of this SAFO is incorporated into operational policy, provided to pilots during ground training, and reinforced in flight training and proficiency checks.

Contact: Questions or comments regarding this SAFO should be directed to the Air Carrier Training Branch, AFS-210, at (202) 267-8166.

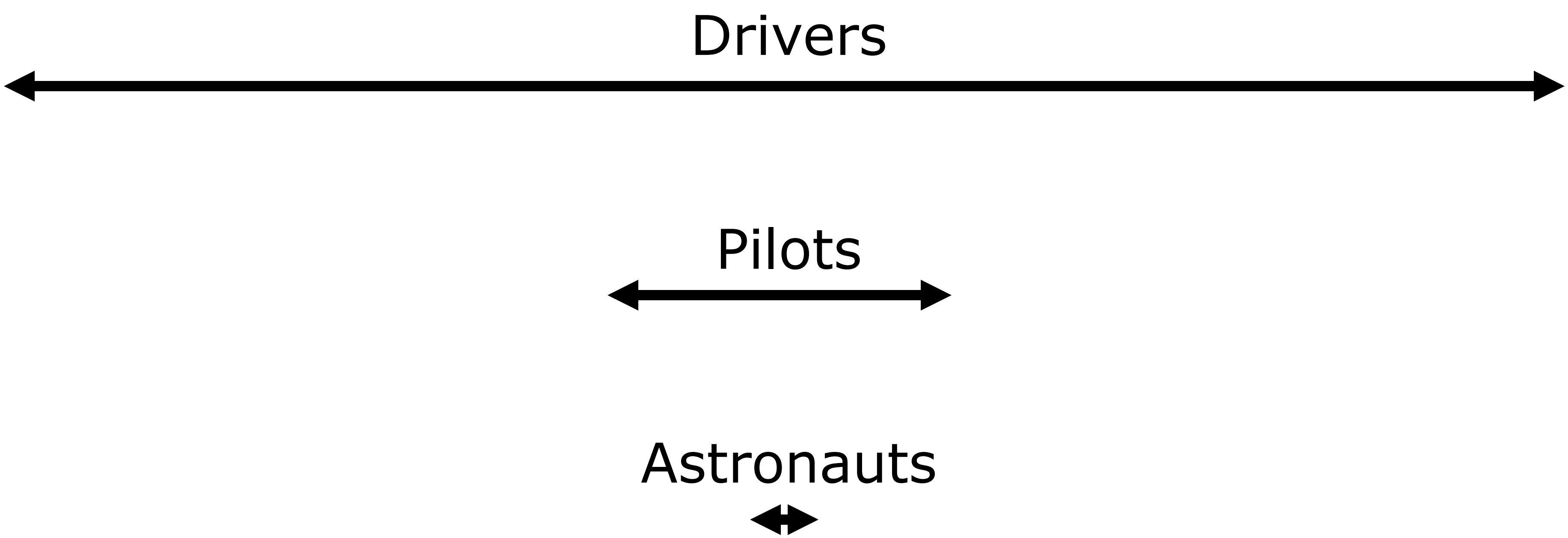
Distributed by: AFS-200 OPR: AFS-210

Education

"One of the myths about the impact of automation on human performance is as investment in automation increases, less investment is needed in human expertise"

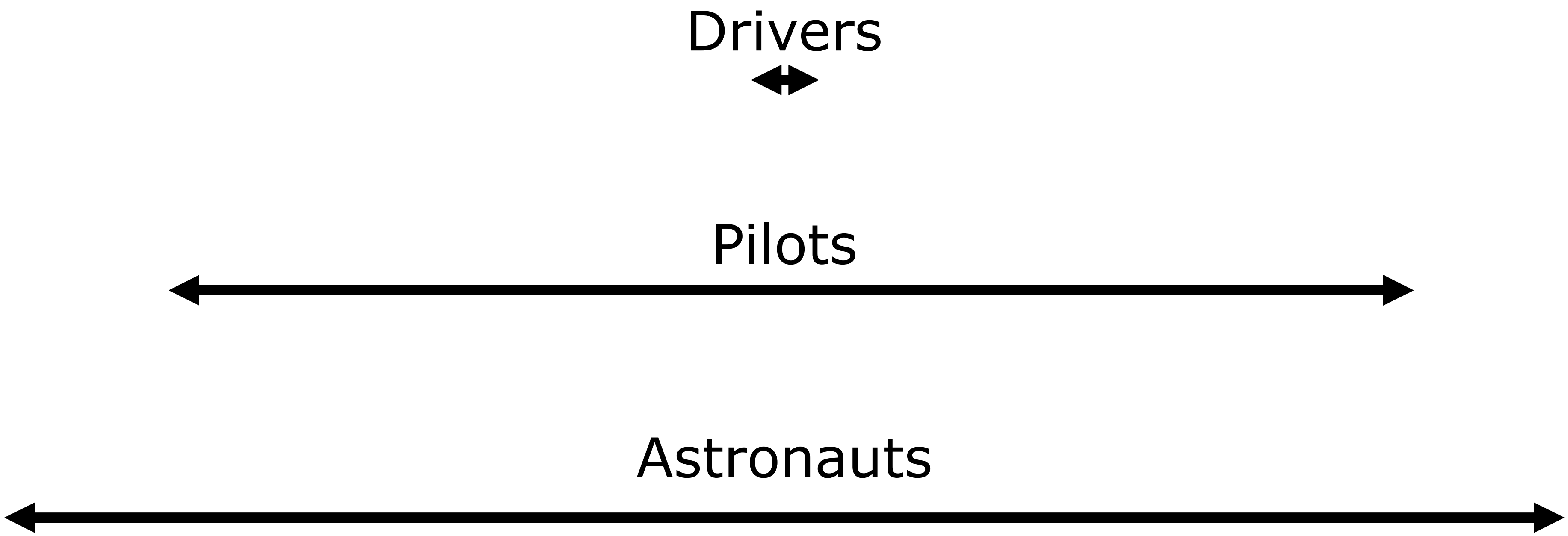
(David Woods as quoted by Robert Sumwalt, 2012)

A Simple Way to Think of Operator Behavior Variability



Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu

Motivation to Learn and Maintain Focus



Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu

Human Centered Automation

A key to safety?

"The human is seen as an essential element in the system for monitoring the automation, to act as a supervisory controller over the [automation], and to be able to step in when the automation fails."

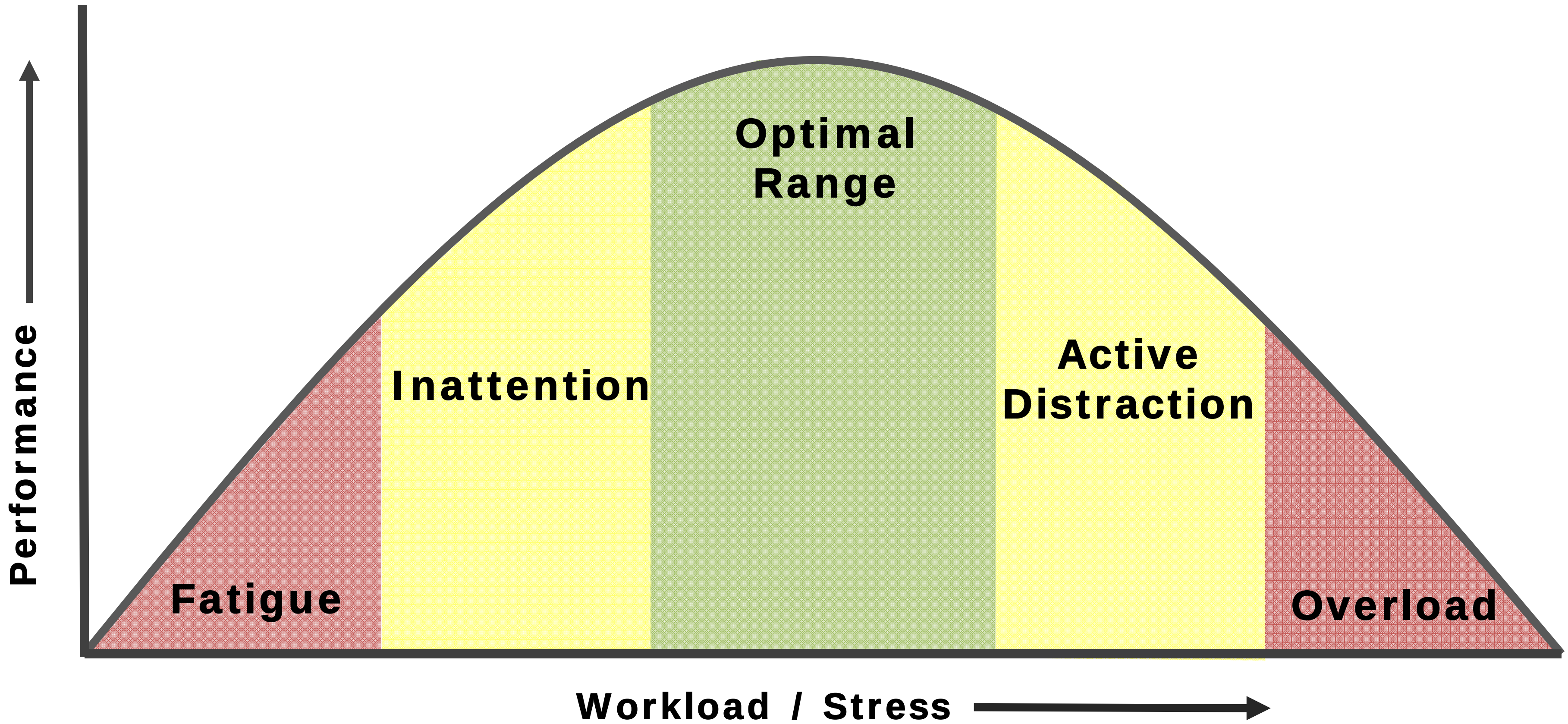
"But it has been become evident that the human, when put in the role of monitor, supervisor, and automation backup in the case of failure, may not perform well."

Sheridan (1995), Human centered automation: oxymoron or common sense?

Workload & Performance

Yerkes-Dodson Law

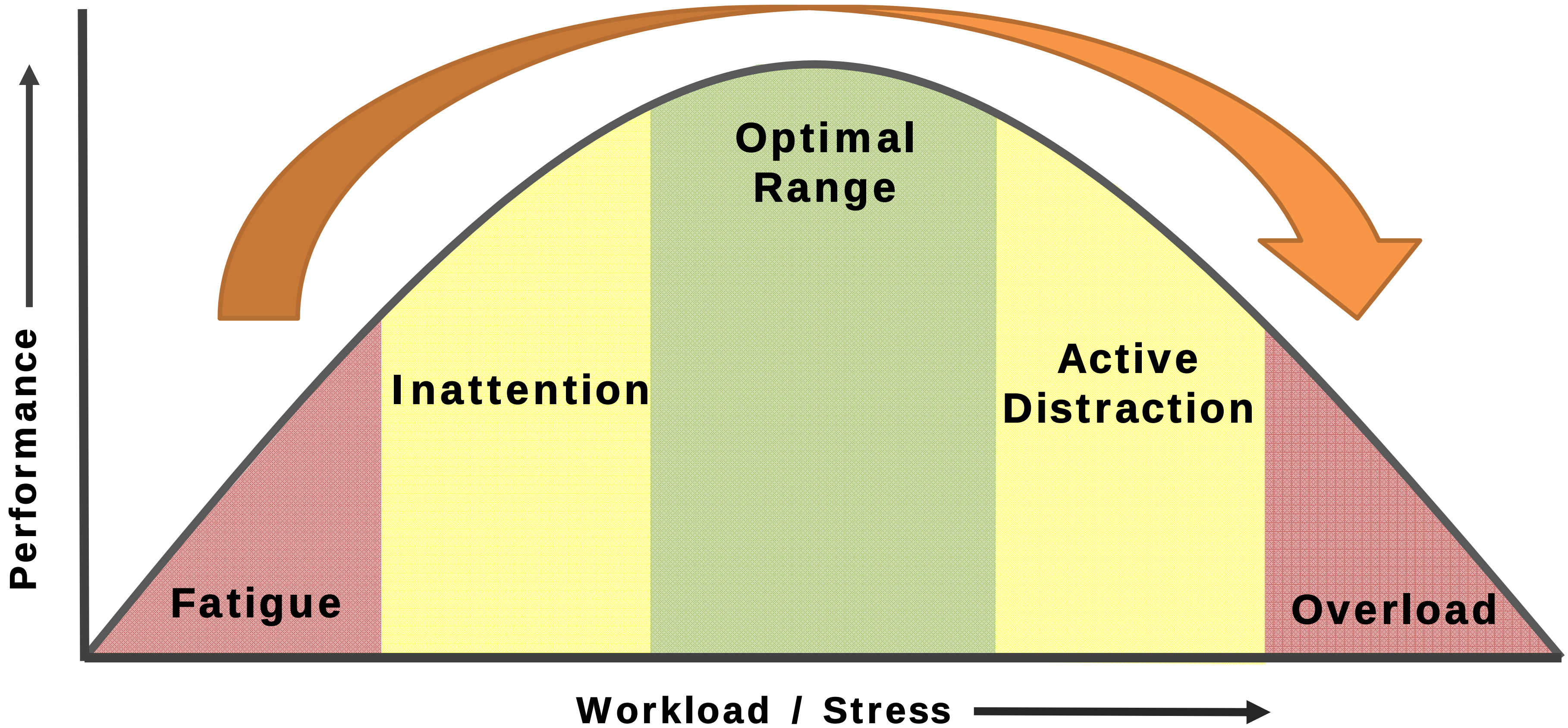
The relationship between performance and physiological or mental arousal



Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu

Workload & Performance

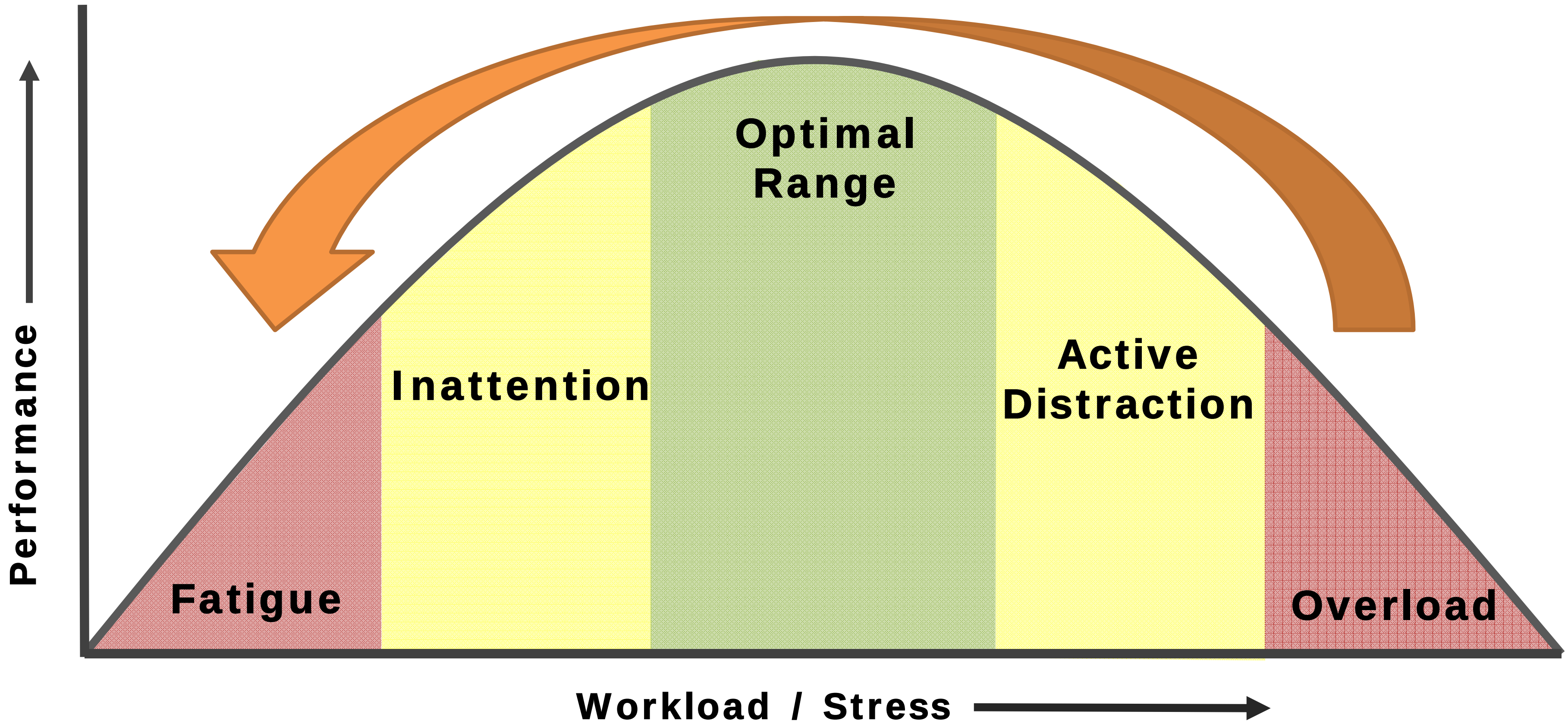
More Information in the Vehicle Tends to Increase Workload



Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu

Workload & Performance

Automation Tends to Lower Workload



Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu

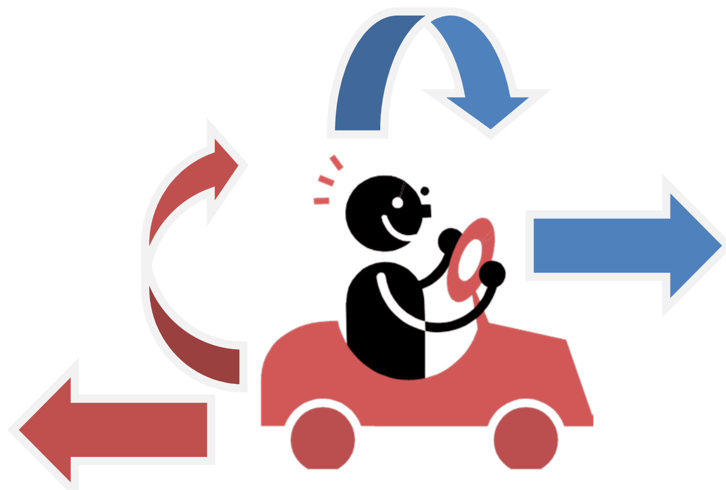
 MIT AGELAB MIT

Physiological Measures

A method for detecting over-arousal and possibly under-arousal (fatigue, inattentiveness)

This can provide:

- Input to workload management
  (reduce low priority information display and minimize automation induced monotony)
- Input to active safety
  (automatic collision response)
- Input to passive safety
  (next generation advanced collision notification)



Our vision of aware vehicles where the driver is an active, not passive, part of the system. (Reimer, Coughlin & Mehler, 2009)

Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu

Physiological Arousal
What Can We Study in the Car?

Part of a larger project evaluating various methods of detecting driver state

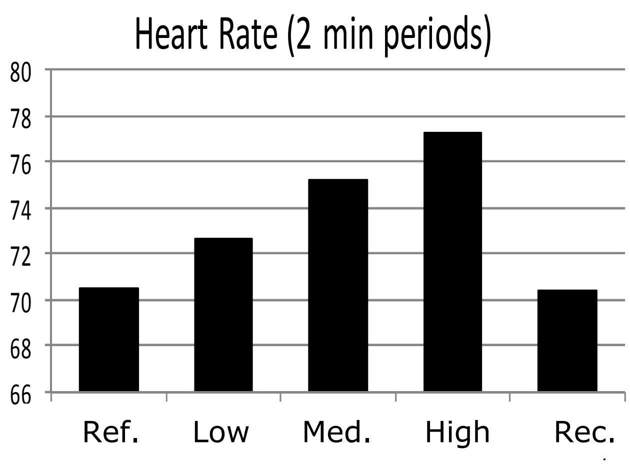
- Measures initially considered:
  - Heart Rate
  - Heart Rate Variability
  - Pulse height (peripheral blood flow)
  - Skin Temperature
  - Skin Conductance
  - Skin Conductance Response
  - Respiration Rate
  - Pupil diameter
  - Muscle Tension
  - EEG (brain waves)
  - Stress Hormones
  - fNIRS

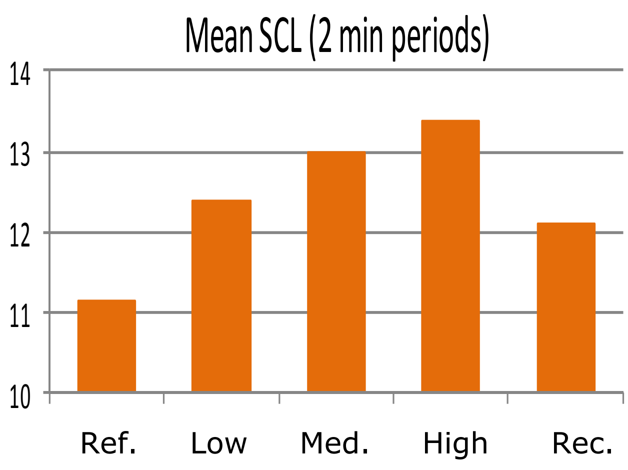
- Which measures will prove most sensitive at differentiating levels of demand?
- What minimum set of measures is required to quantify changes in driver state that provide a robust understanding of arousal and attentional focus?

(drawn in part from Mehler et al., 2009)

Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu

Heart Rate & Skin Conductance Response to 3 Levels of Added Workload





- Both increase with task difficulty (p <.001)
- Heart rate (HR) changes essentially linear with demand; rapid recovery
- Skin Conductance (SCL) reactivity at low demand suggests emotional component; slower recovery

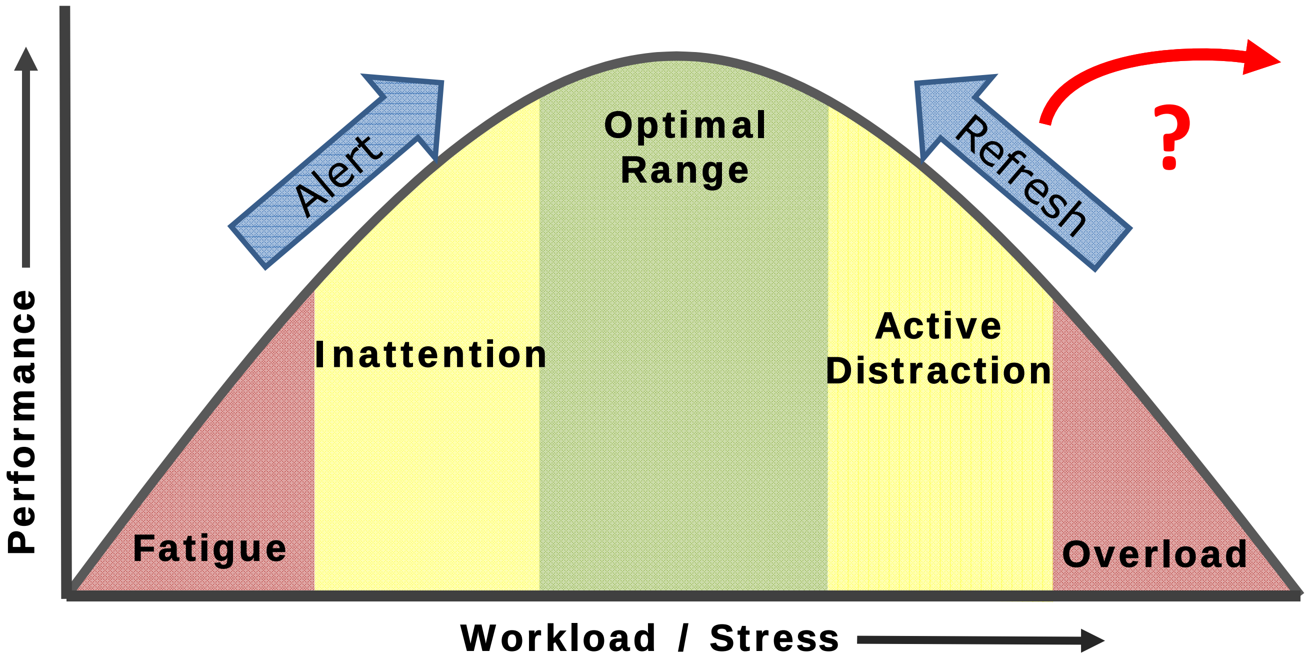
(Mehler, Reimer & Coughlin, 2012)

Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu

Aware Vehicles

Individualized Real-time Feedback for the Driver

- Improve self control
- Increase trust (person as an active vs. passive partner)
- Tailor to individual reactivity profiles and capacity

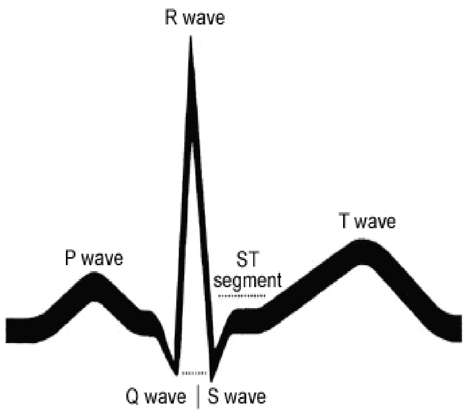


(Coughlin, Reimer & Mehler, 2011)

Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu

Other Applications of Physiological Monitoring

- **Design assessment and optimization:** minimize cognitive workload and distraction associated with in-vehicle and handheld technology usage – method of classifying over taxing non-visual demands?
- **Health state detection:** monitoring diabetes or cardiovascular conditions – warning that attention may be compromised?
- **Emergency response data:** store short term EKG prior to crash and provide as supportive information to emergency medical teams – optimize the golden hour?

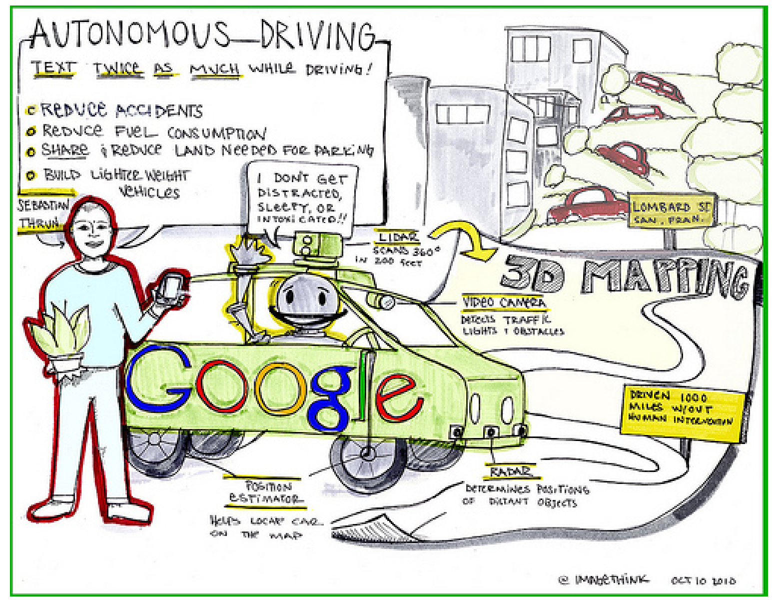


Heart Rate (EKG)

Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu

In Summary, I Believe We Need To:

- Continue exploring technologies for autonomous vehicles
- Make parallel investments in developing our understanding of how to optimize the human's connection with autonomous systems
- Clarify the benefits and consequences of system use and misuse
- Learn from complementary domains
- Stop assuming that autonomy alone will solve our nation's transportation problems



Correspondence > Bryan Reimer, Ph.D. > (617) 452 – 2177 > reimer@mit.edu

Contact

Bryan Reimer, Ph.D.

Bryan Reimer is a Research Engineer in the Massachusetts Institute of Technology AgeLab and the Associate Director of the New England University Transportation Center. His research seeks to develop new models and methodologies to measure and understand human behavior in dynamic environments utilizing physiological signals, visual behavior monitoring, and overall performance measures. Dr. Reimer leads a multidisciplinary team of researchers and students focused on understanding how drivers respond to the increasing complexity of the operating environment and on finding solutions to the next generation of human factors challenges associated with distracted driving, automation and other in-vehicle technologies. He directs work focused on how drivers across the lifespan are affected by in-vehicle interfaces, safety systems, portable technologies, different types and levels of cognitive load. Dr. Reimer is an author on over 70 peer reviewed journal and conference papers in transportation. Dr. Reimer is a graduate of the University of Rhode Island with a Ph.D. in Industrial and Manufacturing Engineering.

reimer@mit.edu
(617) 452-2177
http://web.mit.edu/reimer/www/